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CONTENTS

The fungicidal power of lime and inert powders, p. 81.

Third contribution to the locust bibliography (*continued*), p. 92.

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INTERNATIONAL BULLETIN
OF PLANT PROTECTION

1944 Nos. 11 & 12

THE FUNGICIDAL POWER OF LIME AND INERT POWDERS *

The use of hydrated lime as a fungicidal product dates back to the epic period of the fight against downy mildew of the vine (*Plasmopara viticola*). If it were desired to trace back the history of the question, even for Italy alone, it would be sufficient to peruse the Italian agricultural periodicals for the ten-year period 1880-90, as well as the annals and acts of the academies and experiment stations which, round about that time, earnestly tried out all the products suggested for the control of downy mildew.

Lime, as is known, was the only product employed against this fungus in Italy before the general use of copper washes ; it was adopted on a wide scale chiefly in North Italy and especially in Veneto between 1883 and 1887. In 1888, the use of copper salts completely substituted that of lime which would never have returned in Italian wine-growing, if the present shortage of copper had not made it necessary to find other products without or practically without copper, to replace the classic copper-containing fungicides.

PEGLION declared himself in favour of again employing lime ; this was to be expected from a co-worker of CUBONI [1] who at Conegliano was the most insistant defender of lime as a fungicide. Moreover, some years ago, VERMOREL and DANTONY (1922) maintained that vines could be protected by a weekly treatment of milk of lime ; RAVAZ and VERGE (1921) observed that lime of 1 : 70,000 to 1 : 80,000 strength checked the germination of the conidia of the agent of downy mildew [2].

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* Communication from Professors R. CIFERRI and E. BALDACCI, Botanical Institute of the University and Italian Cryptogamic Laboratory, Pavia, Italy.

[1] CUBONI was sometimes injust : thus, in the controversy with BRIOSI, he did not give GAROVAGLIO his due as being the first to affirm, in 1881, that lime is, without doubt, the simplest, most economic and surest means of controlling downy mildew. (*Riv. di Vit. Enol. Ital.*, Conegliano, 1886, **10**, 225-231 ; 385-393 ; 436-438); against COMES also and in the controversy with THÜMEN.

[2] At this time, however, ideas were so confused that CARPENÈ, one of the followers of the 'Dieu lait de chaux' (*Riv. di Vit. Enol. Ital.*, 1886, **10**, 257-262, which had even opened a periodical column entitled 'Cronaca dell'idrato di calcio'), with reference to an article on copper by CARTANI (*Giorn. Vinic. Ital.*, 1886, Nos. 17-18), declared that 'it was not serious' to concede an effective action of $CuSO_4$ in weak solution, as in the water the copper sulphate would be rendered insoluble (*sic*).

The credit of having introduced, in practice, the use of milk of lime against downy mildew, goes to the brothers BELUSSI, following they experiments the carried out in 1882 and 1883. A year later, CETTOLINI (1884) continued experiments, from then on conclusive, at the School of Wine-growing at Conegliano. Consequently, in 1885, the technicians at Conegliano considered that they could affirm through CUBONI that 'milk of lime' of a 'marvellous efficacy' had 'now solved the problem of downy mildew'[3]. In 1886, the same CUBONI placed milk of lime on the same level as concentrated Bordeaux mixture. In the meantime, however, the discovery of the efficacy of the copper lime wash by MILLARDET (1883) and the already conclusive experiments of 1884 and 1885 led to similar experiments being made in Italy. Copper had found convinced champions in the schools of Piedmont and Campania. In August, 1886, the Ministry of Agriculture, Industry and Trade appointed a Commission charged with studying methods suitable for controlling downy mildew of the vine[4]; this Commission published the proceedings including the reports of the different sub-commissions, schools, institutes and others. In all there were 51 reports based chiefly on the results of 42 experiments carried out at stations and institutes as well as in experiment schools and laboratories throughout Italy.

From this extensive well coordinated experiment work, the Commission was able to draw up the following list of products in decreasing order of efficacy: first, 0.1 to 0.3 per cent. copper sulphate or ammoniacal wash with 0.25 per cent. Cu SO, and as much ammonia; second, Bordeaux mixture with half or less than half the copper first proposed by MILLARDET[5]; third, milk of lime with 6 to 10 kg. and more per hectolitre. Thus, before 1887, the Ministry of Agriculture accepted the conclusions of the Commission and recommended them to wine-growers, in agreement with the results and resolutions of the International Congress which was held at Florence in 1886.

Since then the controversy between the partisans of milk of lime ('lattisti') and copper sulphate ('ramisti'), as they were called in Italy, gradually died down,

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[3] It is to be believed that the results obtained with milk of lime against mildew between 1883 and 1885 were excellent because, during these years infection only became severe during the summer or even at the end of summer (September). Thus, in 1883, although the disease made its appearance in June, it did not become serious until mid August (at Conegliano: see CUBONI), and the spring attacks only appeared later; infection occurred progressively, earlier and earlier up to spring. It was only when the annual cycle of parasitism was established that the inadequacy of milk of lime was seen, but by then the use of copper lime wash had already become common.

[4] TARGIONI-TOZZETTI, Chairman; NAGARI, Secretary; BRIOSI, CANTONI, CARLUCCI, CAVAZZA, CERLETTI, COMBONI, CUBONI, DI ROVASENDA, MIRAGLIA, PIROTTA, SEGAPELI and ZECCHINI, members.

[5] In France, they began with a very concentrated mixture containing 6 kg. of copper and 12 kg. of lime per hectolitre; but already MILLARDET and GAYON had gradually reduced proportions to 1 kg. of copper sulphate and the third of a kg. of lime. A Circular of the Ministry of

all the more so in that at Conegliano, the stronghold of the 'lattisti' CUBONI [6] himself had to acknowledge in 1888, the efficacy of copper salts, following experiments made at Alba and Barolo, even in respect of mildew on the bunches. Immediately after, GRAZZI SONCINI who had succeeded CETTOLINI in directing the School of Conegliano, recognized the superiority of copper over lime [7] both at 0.1 to 0.3 per cent. $CuSO_4$, as in the form of Bordeaux mixture of 10 : 5 : 100 to 2 : 6 : 100 plus 1 of osteocolla. On the other hand, the controversies as well as the experiments they provoked were very useful, since they clearly showed that if, on the one hand, copper and its derivatives are definitely superior to lime as means of preventing downy mildew, lime, on the other hand, among the numerous preparations without copper suggested in the course of these years, proved to have a relatively satisfactory effect.

FUNGICIDAL ACTION OF INCREASING DOSES OF LIME

Aqueous suspensions (in boiled distilled water) of calcium hydrate were prepared extemporaneously with increasing doses of pure calcium oxide.

On nebulizing these suspensions onto the usual slides, and by effecting germination tests with the improved MCCALLAN method *, the germinations of 13,500 conidia in all were checked over.

The following results were obtained : —

Kg. per hl. : —	Non germination
0.05	9 %
0.10	8 %
0.15	9 %
0.20	31 %
0.25	32 %
0.50	34 %
0.75	34 %
1.00	36 %
1.50	37 %

Agriculture in 1887 again recommends the use of Bordeaux mixture — 4 : 3-4 : 100, or 0.2 to 0.25 per cent. $CuSO_4$ or 8-10 per cent, milk of lime, when then the I.R. Association of Agriculture advocated at first 5 : 5 : 100, afterwards 3 : 1. 5 : 100 (see FÜRHAUF, *Rass. Vit. Enol.*, 1887, **1**, 362).

[6] Already at the Congress and National Competition for vine diseases which were held a Florence in 1886, CUBONI (who advocated milk of lime not only at 4 per cent. but also at 4-7 per cent.) acknowledged the complete succes of Bordeaux mixture according to one of the formulae of MILLARDET (4 : 7.5 : 100) and of $CuSO_4$ at 0.4 per cent., at the same time considering the action of copper salts as being equal to that of milk of lime.

[7] The controversy continued however ; on the one hand, copper was opposed for its high toxicity to man — which gave rise to a veritable phobia of copper — and for its price ; on the other hand, lime was opposed for the cost of labour required for treatments which had to be repeated from four to six times a month (with the difficulties caused by shortage of water in Southern and Insular Italy), the difficulty of spraying with a mixture containing 10 and even more kilos of lime per hectolitre, etc. ; for a long time animated discussions continued between the partisans of liquid treatments and those of copper dusts.

* See this *Bulletin* 1944, Nos. 9-10, pp. 65-72.

Kg. per hl.: —	Non germination
2.00	40 %
3.00	39 %
4.00	50.5 %
5.00	58 %
6.00	63 %
7.00	67 %
8.00	71 %
9.00	76 %
10.00	81 %

From the 0.05 per cent. (50 gm. per hl.) concentration up to the 10 per cent. (10 kg. per hl.), three levels of extinction of the germinability of the conidia are seen. In fact, up to a concentration of 0.1 per cent., germination is practically equal to that of the control without lime ; at 0.2 per cent., there is a loss of approximately a third in germination ; this diminution in germinability slowly increases to 3 per cent., when the germinated conidia are about three-fifths ; from 3 to 10 per cent. the extinction of germinability is more rapid and finally amounts to four-fifths of the conidia present.

It was not possible to carry out similar experiments on the conidia of downy mildew of the vine, because with strong lime concentrations the particles of calcium make it difficult to distinguish the germinated from the non-germinated conidia, and the zoospores are very hard to discover.

This anti-germinative action of lime may be explained in two ways : by a chemical action and by a physico-chemical and mechanical checking action. The basic chemical action may be attributed to increasing alkalinity ; the threshold of 0.2 per cent. in fact, corresponds to that of the saturation of the solution of calcium hydrate (approximately 0.16-0.17 per cent. at environmental temperature). By way of verification, the germinability was tested of conidia of *Alternaria* type *tenuis* and the conidiangia of *Pl. viticola* with different *p*H levels, namely, *p*H = 1.9, *p*H = 9.6. The results were as follows :

	Alternaria *	*Plasmopara* †
*p*H = 1.9	94	low
» = 1.9	82	»
» = 3.7	77	average
» = 4.9	13	high
» = 7.0	7	»
» = 8.0	5	average
» = 9.0	6	low
» = 9.6	5	»

For *Alternaria*, germinability is low up to a *p*H of 3.7 ; it subsequently increases abruptly at *p*H = 4.9, and attains the optimum between *p*H = 7.0 and *p*H = 9,

* Non - germination of conidia.

† Non - germination of conidiangia.

again falling when *p*H is 9.6. The germinability of the conidiangia of *Plasmopara* is low between *p*H = 1.9 and *p*H = 2.7 and with a *p*H of 9.0 and 9.6 ; it is average when *p*H = 3.7 and 8.0 ; it is high (normal) between *p*H = 4.9 and *p*H = 7.0. Therefore, there is a distinct threshold in the scale of acidity for *Alternaria* and two thresholds in the scale of acidity and alkalinity respectively for *Plasmopara*. Consequently, the change in the reaction of the medium is not sufficient to explain the diminution of germinability by calcium hydrate, although the saturated solution of pure calcium hydrate has a reaction above *p*H = 10. Besides, RAVAZ and VERGE (1921) had already noted that sodium carbonate is active against mildew at a dilution of 1 : 7,000 or 1 : 8,000, while calcium hydrate is active at a dilution of 1 : 70,000 or 1 : 80,000, and concluded that it is not only the alkalinity of the medium which acts as anti-germinative factor of the conidia.

ACTION OF LIME AND INERT POWDERS

In order to study the eventual physico-chemical and mechanical action, opposed to the germination of conidia, conidia of *Alternaria* were made to germinate in chemical inert powders, such as talc (*p*H = 7.1) and bentonite (*p*H = 8.1-8.6) in mixtures at 8 per cent.

It was observed that the impeding action was reduced on germinations, while it was evident on the average length of the germinative tubes. By establishing three categories of average length (visible to the eye) : (*a*) tubes little developed up to double the length of the conidia : (*b*) tubes fairly developed, about five times the length of the conidia ; (*c*) tubes very developed exceeding five times. the length of the conidia, after three days incubation at 20-21°C., the following data were obtained : —

Tubes	*a*	*b*	*c*
Control (in water)	17 %	35 %	45 %
Lime	72 %	18 %	10 %
Bentonite	66 %	18 %	16 %
Talc	53 %	38 %	9 %

As is seen from this table, the mechanical checking action is greater with lime than with the other products, since the chemical action is combined with the mechanical or physico-chemical action. With our present knowledge, only vague hypotheses can be made as to the nature of this latter action.

Since neither in this way the efficacy of lime could be fully explained, a different experiment was tried, unfortunately under conditions difficult to reproduce and measure, by nebulizing slides with an 8 per cent. suspension of lime so as to cover them practically entirely, then leaving them to dry in the air. Immediately afterwards, they were sprayed with a suspension of conidia of *Alternaria*, and again left to dry in the air. Finally, the slides were placed on the cover of a Petri dish containing crushed ice and the whole was covered with a bell glass open at the top. By using a jet of steam at 100°C. produced by an autoclave containing boiling water, an endeavour was made to obtain by means of a glass tube attached to the

bell glass, the condensation of the steam in the form of drops, like dew, on the cooled slides. By emitting intermittently steam for a duration of about one second each time, it was seen that the condensation drops of the first four or six emissions were rapidly absorbed by the thin layer of calcium, after which the final emissions caused the formation of condensation drops. Now, while on the slides having no condensation drops, placed in a moist chamber in the thermostat, germination of the conidia was very reduced, on those containing condensation drops, germination was normal (examination of the slides by transparency presented difficulties and was effected mainly by reflection).

Although the above data are approximate, it may be presumed that the fungicidal action of lime on vine leaves is twofold : chemical because of the alkalinity of the solution, and physical because of the absorption of the condensation drops. Although it may be affirmed that the presence of drops of water is not an absolutely necessary factor for the germination of conidiangia, it is probable that this action of the absorption of water checks appreciably their germination and still more so the germination of the zoospores of *Plasmopara*. It is known, in fact, that when vines are located in an area protected from the condensation of atmospheric water vapour, they are less easily subject to infection caused by mildew ; for the same reason, tall vines climbing trees are less attacked than low-growing vines. These observations had already been made in the early years of the appearance of mildew in Italy [8].

Carbonation of lime in air

Already at the end of the last century, it was observed that treatments with lime had, in order to obtain any results, to be repeated very frequently ; however, the frequency of applications varied from one experimenter to another. The reason was clearly indicated, *inter alia*, by Ravaz and Verge, who noted that calcium hydrate on contact with the carbon dioxide of the atmosphere easily passes into the carbonate state, so much so that after only 24 hours, a 6 per cent. milk of lime sprayed on vine leaves in a moist chamber no longer gives an alkaline reaction to phenolphthalein, and that after an hour on the surface of the sprayed milk of lime, a pellicle of calcium carbonate crystals is already formed. Flor (1932) found that

[8] We believe that the first observations on the possibility of preventing mildew infection by not letting drops of water condense on the leaves, are those made by Cuboni (1885). They also followed observations in Italy by Negri, Gerini and Cettolini, and in France by Maleque, who noted that " the vines on which dew does not form because protected by trees, a roof or by some other means, are only slightly or not at all attacked by mildew " (see also Cettolini, 1883 and 1884). It is of interest to observe that Cervi (*Giorn. d'Agric.*, 1943, n. 21, p. 125) proposed a system of mechanical protection of vines against mildew by shaking the vines and dusting them with absorbent dry powders. While maintaining a reserved opinion on the practical value of such a system applied on a large scale, it should not, however, be neglected as a basis for experiment, noting that, for mildew infection to be established; it is not absolutely necessary for the leaves to be covered with dew or drops of water, and it cannot be excluded that during the night conditions favourable to infection are not produced.

the carbonation of calcium hydrate varies in relation to temperature and moisture, so that the transformation into carbonate of a thin layer of milk of lime within the space of a few hours frequently occurs during the hottest hours of the day. VERMOREL and DANTONY (1922), on the contrary, found that carbonation was practically complete after 5 or 6 days on using milk of lime rendered adhesive by means of casein (the limit of 4 to 8 days was on an average that indicated towards 1885 for efficacy against mildew.

In a further experiment, a wash of pure calcium hydrate, prepared at the time, was sprayed rather densely onto ten plates of window glass measuring 30 × 40 cm. The suspension of lime (3 kg. per hl.) dried in the air on the plates formed a practically homogeneous layer.

First dried slightly in the laboratory, the plants were subsequently exposed outside in the shade between the leaves of espalier vines, during the first days of July; they were hooked very closely together to the vine shoots. One of the plates was kept as control and its $CaCO_3$ content was determined volumetrically one hour after nebulization; on each of the days which followed, at the same hour, one of the plates was taken in, all the lime was scraped off and the $CaCO_3$ content determined. No rain fell during these days and the weather kept warm and breezy.

The following results were obtained: —

$CaCO_3$ CONTENT OF THE LIME

In the laboratory (*A*) and in the open (*B*).
Immediately after nebulization (control) 0.47 per cent.

	(*A*)	(*B*)
After 1 day	14.3 per cent.	36.4 per cent.
» 2 days	26.6 » »	59.2 » »
» 3 »	41.0 » »	78.4 » »
» 4 »	57.8 » »	96.3 » »
» 5 »	70.1 » »	95.2 » »
» 6 »	89.5 » »	96.0 » »
» 7 »	93.2 » »	96.3 » »
» 8 »	95.0 » »	96.4 » »
» 9 »	90.9 » »	95.8 » »

The daily determination during the nine consecutive days gave these results: milk of lime when scarcely dry contains less than 0.5 per cent. calcium carbonate; carbonation of the lime exposed to the air in the laboratory after 2 or 3 days amounted to a third or over; after 4 or 5 days it attained half or two thirds; and after 6 days or more, it was practically complete (nine tenths). Carbonation was more rapid on the plates placed between the vine leaves, and thus after 3 or 4 days, the transformation of the calcium hydrate into carbonate was practically complete.

These results agree and justify the assertion of the experimenters (mainly in the period which just preceded the use of copper salts against mildew) which affirms that to have some efficacy spraying of the vines with lime has to be repeated very frequently.

It could be presumed from the formation of small crystals of calcium carbonate easily seen under the microscope that the physical anti-germinative action of milk of lime undergoing the process of carbonation is less than that of milk of lime without $CaCO_3$, the action due to alkalinization of the medium remaining identical, since after 9 days testing, sufficient hydrate was left to saturate the solution. Experiments on the absorption of the drops of condensation water on the plates with milk of lime exposed among the vines, and the germination experiments with conidia of *Alternaria* having been repeated, it was noted that the physical anti-germinative efficacy was reduced to practically a twentieth and the mechanical efficacy to less than a tenth compared with milk of lime freshly prepared.

Efficacy of commercial lime

The efficacy of slaked lime found in commerce, however, differs greatly, as it always contains an appreciable percentage (and sometimes high) of calcium carbonate.

Below are given the results of the toxicity experiments effected as above with four types of crude lime of different origin : —

Lime A. — Commercial, $CaCO_3$ content . . . . . 16.7 per cent.
Lime B. — Commercial, $CaCO_3$ content . . . . . 26.0 » »
Lime C. — Obtained from a farmer, $CaCO_3$ content . 18.1 » »
Lime D. — Commercial, $CaCO_3$ content . . . . . 72.6 » »

Diminution in germinability of conidia

Dose (kg. per hl.)	(*A*)	(*B*)	(*C*)	(*D*)
1	5	2	14	36
2	9	5	18	40
3	12	11	20	39
4	17	15	28	51
5	25	21	37	58
6	31	27	43	19
7	41	35	48	29
8	53	44	60	27
9	60	49	71	30
10	67	56	81	50

A higher $CaCO_3$ content corresponds roughly to a lower fungicidal action of the lime, as was to be expected, though with considerable variations between one lime and another, and one series of experiments and another.

The fungicidal efficacy of commercial lime or that obtained from farmers, therefore, may be reduced greatly by carbonation which may attain very high levels.

In the preparation of Bordeaux mixture, carbonation has much less importance,

at least from the standpoint of alkalinity to be attained, since these limes always contain sufficient hydrate to saturate the aqueous solution [9].

FUNGICIDAL EFFICACY OF LIME ON VINES UNDER GLASS ARTIFICIALLY INFECTED WITH MILDEW

Using the equipment at our disposal to produce in a small glass-house with regulated temperature artificial infection of destructive force on the leaves of young vines specially grown we tried the effect of milk of lime as a protection against mildew

To this end, at the same time, heavy spraying with a suspension of 8 per cent. 'Rumianca' lime was carried out on a series of vines. The lime was left to dry and then part of the vine plants was inoculated with conidia of *Plasmopara*. On other plants already treated with lime, a fresh inoculation was effected the following day ; on another group of the same lot, another inoculation was again made on the third day and so on up to 9 days after spraying with milk of lime.

The following results were obtained : —

Fungicidal treatments of the vine with lime

	Mildew		Coefficient	Protection
	diffusion	intensity		
After 0 days (immediately after spraying)	1	3	6	appreciable
» 1 day	2	5	3	weak
» 2 days	3	5	2	very weak
» 3 »	(results incertain)			—
» 4 »	4	5	1	insignificant
» 5 »	(results incertain)			—
» 6 »	4	5	1	insignificant
» 7 »	(results incertain)			—
» 8 »	3	6	1	insignificant
» 9 »	4	6	0	nil

Controls gave the following results : —

Treatment with 1 per cent. 'Caffaro' powder:

	Mildew		Coefficient	Protection
	diffusion	intensity		
For 10 consecutive days	0	0	10	complete

[9] The problem of the solubility of lime in water — which interests pharmacology, since all the pharmacopoeias include lime water among the formulae — was examined by MORMET (1936). This investigator after having noted the different conditions required by the different pharmacopoeias and the different tolerances allowed, notes that the solubility of lime in water varies because of various factors still imperfectly known, although diminishing with increase in temperature ; the pharmacopoeias, in fact, give from 1.5 to 1.7 gm. of Ca $(OH)_2$ for 100 gm. of solution between 15° and 25° C.

The series of data with temperature between 2° (or 15°) and 80°C. of HEYFELD (1827) and MOODY and LEYSON (1908) reported by MORMET, also shows a certain variation, especially with the maximum temperatures tried.

Without treatment (aspersion with water).

	Mildew		Coefficient	Protection
	diffusion	intensity	—	—
For ten consecutive days	5	5	0	nil

By way of comparison, dustings with two inert powders were effected: bentonite ($pH = 6.2$) * and talc ($pH = 7.1$), with which the following results were obtained:

	Mildew		Coefficient	Protection
	diffusion	intensity	—	—
Bentonite	2	4	4	Appreciable
Talc	1	4	5	Average

These data are the evident proof of the value of lime as a fungicide. If inoculations with conidia of *Plasmopara* are effected the same day as treatment with milk of lime, an appreciable protection against mildew is observed; after 24 hours, the fungicidal power is already reduced to half and is quite inadequate from the practical standpoint; after 48 hours, it is minimum and becomes insignificant the following days until it is zero on the ninth day after treatment.

The action of bentonite (slightly acid) and that of talc (almost neutral) resembles that of lime though to a slightly lesser extent, which confirms the fact that the action of lime (and the other powders tried) is chiefly physico-chemical or mechanical and not chemical.

Discussion of results and conclusions

We may conclude from these experiments that:

(1) In regard to *Alternaria*, milk of lime exercizes a triple anti-germinative action:

(*a*) chemical, through alkalinization of the solution, action which is slight; the solution is saturated with 0.16-0.17 per cent. calcium hydrate;

(*b*) mechanical, which is much more effective, but which is strong only at very high concentrations (8 to 10 kg. per hl.) and which also takes place with suspensions of inert powders (talc and bentonite);

(*c*) physical, through the absorption of drops of condensation water on the surface of the leaves (dew, etc.).

It may be supposed, without deviating from the truth, that similar anti-germinative action occurs with the conidiangia of *Plasmopara*.

(2) In the open and under conditions which approach natural conditions calcium hydrate carbonates very rapidly, and perhaps owing to the change in its physical state, the mechanical and physical anti-germinative action of lime becomes less efficacious following the formation of small crystals of calcium carbonate. On

* 12,000-16,000 mesh fineness, kindly procured by the Litacrom Company at Milan.

the other hand, the chemical action remains intact. The crystals of calcium carbonate are tabular 2.5-5 × 2 μ, but easily group into crystalline blobs ; the dimensions of the particles of ordinary calcium hydrate vary much more, from 2.5 to 4.5 × 2.5 μ in our experiments, and group together irregularly.

It is not in our province to decide whether, after what has been said, there is any economic value in employing milk of lime for treating downy mildew of the vine, but, however, when all is said and done, we would be inclined to conclude in the negative, since to obtain moderate effective results, spraying has to be repeated very frequently during the period when severe mildew attack is likely, namely every 3 or 4 days (at the most every 5 days) with a very dense mixture (over 5 kg. per hl and probably from 8 to 10 kg. per hl.) [10]. Apart from the practical difficulty of careful spraying, the cost of labour would be appreciable [11]. Moreover, we do not know what would be the effect on the growth of the vines of 15 to 20 treatments of very dense milk of lime.

In conclusion, the action of lime as a fungicide would vary in character : —

(1) Chemical action : through the alkalinity of the calcium hydrate in solution ;

(2) Physico-mechanical action : —

(*a*) by action checking the establishment of infection ;

(*b*) by local drying of the drops of condensation water.

(3) Physiological action : by increase in transpiration and step-up in metabolism.

Whatever the effect milk of lime may have on plants, the reasons given above lead us to doubt the practical value of milk of lime as a fungicide.

[10] During the 1942 season, in the Quarto field, Bologna, under the control of Peglion and through the efforts of Ghidini, the fungicidal power of milk of lime was tested and gave practically negative results. It should be noted, however, that mildew attack was so severe and intense that the recognition of products having a mediocre or weak fungicidal action was very uncertain.

[11] We consider that the conclusions of Cavazza at the Congress and International Competition for Vine Diseases held at Florence (October, 1886, are of topical interest : For lime to have any affect, 8 to 10 treatments are necessary with 3-10 per cent. (on an average 5.6 per cent.) lime, which should be made more adhesive, moreover, all limes do not give the same results.

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